NWA 2737

DRAFT

Shocked Dunite

611 grams

Figure 1: Photograph of NWA 2737 (Diderot) kindly submitted by Carine Bidaut and Bruno Fectay. Is that a centimeter scale? Where's this rock now?

Introduction

NWA 2737 (field name "Diderot") is a dark rock, found in the Moroccan Sahara, August 2000, but not recognized as a meteorite until 2004 (figure 1). With 90% modal olivine, it is akin to a dunite, as is Chassigny (Beck et al. 2005; Mikouchi et al. 2005). However, NWA 2737 has a somewhat higher Mg/Fe ratio than that of Chassigny and is highly shocked.

NWA 2737 is not highly altered by weathering. It has low U, Sr and Ba, which are the usual indicators for desert weathering (Barrat et al. 2003). However, the isotopic composition of Sr indicates at least some alteration (Misawa et al. 2005).

After much ado, the name for this specimen of Mars (NWA 2737) is now "official". Apparently, meteorites are NOT named after people, although Mars rocks sometimes are (i.e. Humphry), and some meteorite classes are (i.e. Howardites). It is a shame this rock can't officially be named after Denis Diderot, who was the editor-in-chief of "Encylopedia" and a famous 18th century enlightenment thinker.

Petrography

The texture of NWA 2737 is that of a cumulate (Beck et al. 2005), with olivine and pyroxene the main phases (figure 2). Plagioclase is absent, but minor sanidine is present.

Diffuse X-ray reflections are used to determine a high (?) shock pressure (Mikouchi et al. 2005). The

Mineralogical Mode of NWA2737

	Beck et al. 2005	Mikouchi et al. 2005
Olivine	89.6 vol. %	89
Augite	3.1	3
Pigeonite	1.0	4
Chromite	4.6	3
Sanadine	1.6	1
Phosphate	0.2	

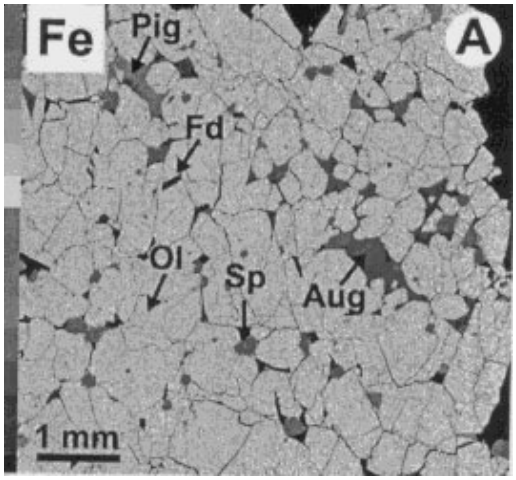

Figure 2 : X-ray map for Fe of polished thin section of NWA2737 showing cumulate texture (figure 2a from Beck et al. 2006).

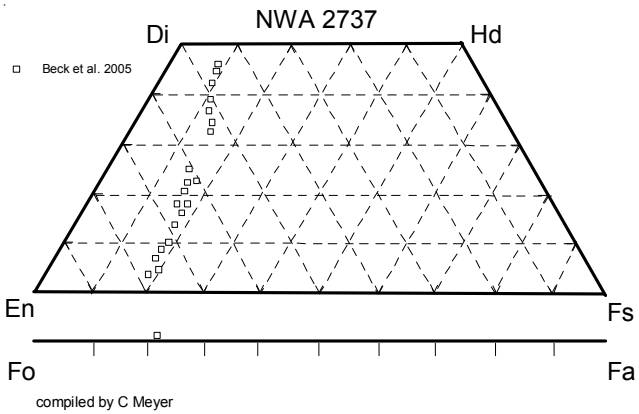

Figure 3: Pyroxene and olivine composition of NWA 2737 (lifted gently from Beck et al. 2005, Mikouchi et al. 2005).

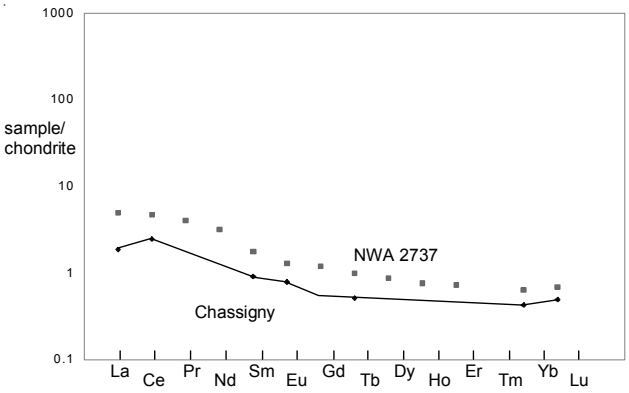

Figure 4: Normalized rare-earth-element diagram of NWA 2737 (data from Beck et al. 2005) compared with that of Chassigny (from Mittlefehldt 1996).

boundary of some calcite-pyroxene grains in NWA 2737 are found to be offset by shock features (Beck et al. 2005); evidence that some of the carbonates in NWA 2737 are from Mars.

Mineralogy

Olivine: Olivine in NWA 2737 is up to 2 mm and is black due to shock (Beck et al. 2005)(see figure 7). It is rather homogeneous and mafic (Fo_{79}). Treiman et al. (2006) find the olivine is "brown" in thin section (as is also the case in some other Martian meteorites), because of the presence of Fe^{+3}. They speculate that shock heating may have released H^{+} from the lattice?! Pieters et al. (2006) have determined the spectra of olivine and list several possible cause for "brown" olivine – all involving shock. McCanta et al. (2006) also reported substantial Fe^{+3} in the olivine. On the other hand, Reynard et al. (2006) found that "black" olivine contained nanophase metallic NiFe (*you cann't have both!*)

Pyroxene: Pyroxenes fall along a tie-line ($En_{80}Wo_{2}$ - $En_{45}Wo_{46}$)(figure 3). Pyroxenes have fine exsolution lamellae (1 micron). Trieman et al. (2006) and Reynard et al. (2006a) calculate an equilibrium temperature of ~1150 deg C from the end member pyroxenes.

Chromite: Chromite shows chemical zoning (Beck et al. 2005; Mikouchi et al. 2005).

Kaersutite: Ca-poor kaersutitic amphibole has been reported as a minor phase by both Beck et al. (2005) and Mikouchi et al. (2005).

K-spar: Sanidine is $An_{1-13}Ab_{68-79}Or_{15-23}$ (Beck et al. 2005).

Phosphates: Apatite has up to 2.7 wt. % Cl

Carbonates: Mostly calcite, but some aragonite.

Chemistry

The composition of NWA2737 was determined by Beck et al. (2005b) (table 1). The rare-earth-element pattern (figure 4) had been previously reported by Beck et al. (2005a).

Radiogenic age dating

Misawa et al. (2005) determined a crystallization age of 1.42 ± 0.06 b.y. by Sm-Nd (figure 5). Marty et al. (2005) reported a K-Ar age of 1.29 b.y. (assuming no trapped ^{40}Ar). Bogard and Garrison (2006) reported an age of 169 ± 4 m.y. from an intermediate temperature

Table 1. Chemical composition of NWA 2737.

reference	Beck et al. 2005	
weight		
SiO2 %	37	(a)
TiO2	0.13	(a)
Al2O3	0.86	(a)
Fe2O3	19.61	(a)
MnO	0.4	(a)
MgO	37.1	(a)
CaO	0.84	(a)
Na2O	0.17	(a)
K2O	0.05	(a)
P2O5	0.1	(a)
S %		
sum		
Sc ppm	4.6	(b)
V	*70*	(a)
Cr	11,700	(a)
Co	78	(b)
Ni	875	(a)
Cu	4.27	(b)
Zn	45	(b)
Ga	1.43	(b)
Ge ppb		
As		
Se		
Rb	1.28	(b)
Sr	27.2	(b)
Y	1.21	(b)
Zr	5.01	(b)
Nb	1.19	(b)
Mo	0.15	(b)
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm	0.063	(b)
Ba	37.5	(b)
La	1.17	(b)
Ce	2.87	(b)
Pr	0.363	(b)
Nd	1.43	(b)
Sm	0.266	(b)
Eu	0.0721	(b)
Gd	0.237	(b)
Tb	0.037	(b)
Dy	0.213	(b)
Ho	0.043	(b)
Er	0.117	(b)
Tm		
Yb	0.105	(b)
Lu	0.017	(b)
Hf	0.14	(b)
Ta	0.07	(b)
W ppb	100	(b)
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm	0.13	(b)
U ppm	0.056	(b)
technique	*(a) ICP-AES, (b) ICP-MS*	

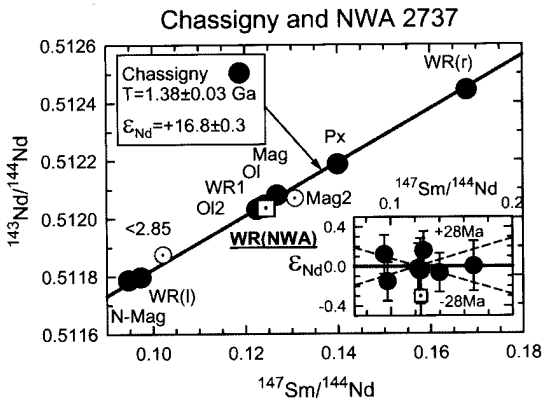

Figure 5: Crystallization age of Chassigny by Sm/Nd with preliminary data for NWA2737 (from Misawa et al. 2005).

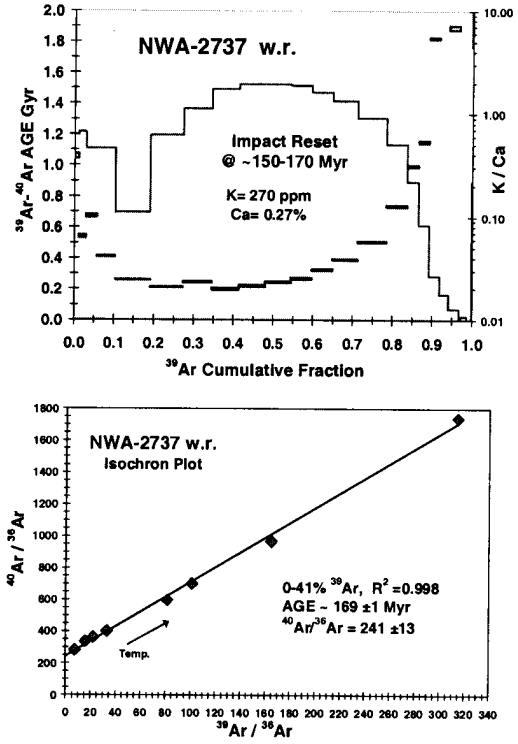

Figure 6: Ar/Ar plateau age for NWA2737 (from Bogard and Garrison 2006).

plateau in Ar/Ar (figure 6). Bogard and Garrison interpret this young age as due to an "outgassing" event.

Cosmogenic isotopes and exposure ages

Tim Jull (private communication) reports that ^{14}C is 16.9 ± 0.7 dpm/kg and ^{10}Be is 19.3 ± 0.4 dpm/kg (close to saturation and typical of nakhlites and Chassigny). From these measurements he calculates a ^{14}C terrestrial age of 9.5 ± 1.3 k.y. and $^{14}C/^{10}Be$ terrestrial age of 9.6 ± 0.4 k.y.

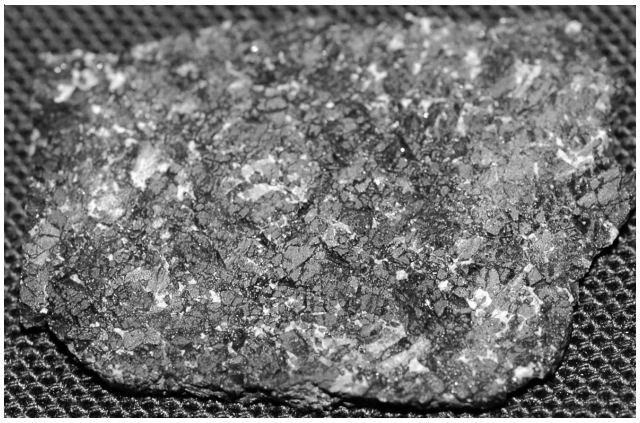

Figure 7: Photo illustrating "black" olivine.

Figure 8: North West Africa where NWA2737 was found (where's the nearest post office?). What's the nomcom going to do about this? Stay tuned.

Marty et al. (2005) apparently determined ~10 m.y. for the cosmic ray exposure (referenced in Mohaptra et al. 2006).

Other Studies

Oxygen isotopes are reported as Delta ^{17}O = +0.305 (Beck et al. 2005), proving its Martian status.

Xenon isotopes have been studied by Mohapatra et al. (2006).